EFFECT OF NITROGEN FERTILIZER ON COTTON HOST-PLANT QUALITY AND ITS IMPACT ON ARTHROPOD COMMUNITY

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Abstract

The relationship between nitrogen fertilizer application in cotton and subsequent changes in lint and seed yield is well-understood. However, little research has been done to evaluate the role of nitrogen fertility in arthropod population abundance in cotton, particularly in a high yield potential subsurface drip irrigation production system. Previous work suggests that there exists a non-linear relationship between soil nitrogen availability and cotton aphid abundance in cotton. However, interactions between plant-available soil nitrogen and moisture ultimately determine arthropod population dynamics, at least for the cotton aphid. Also, there is a lack of information on plant parameter values with respect to varying rates of available soil nitrogen in cotton production. An ongoing multi-year comprehensive field study has examined the effect of soil nitrogen (residual nitrogen plus applied nitrogen) on cotton agronomic growth parameters and arthropod abundances under a drip irrigation production system for 10 years. This paper discusses the results of the Year 11 of this ongoing study. Fixed-rate nitrogen application experimental plots, previously established and fixed consisted of five augmented nitrogen fertility levels (0, 50, 100, 150, and 200 lb/acre) with five replications. Although two synthetic pyrethroid applications were applied to all treatment plots during August 2012 to encourage a cotton aphid buildup, observed aphid numbers remained low for 2012. This year’s arthropod sampling then focused on community composition and relative numbers of other cotton pest and beneficial species among the five nitrogen treatments. Nitrogen augmentation rates significantly influenced all agronomic parameters evaluated in this study, most with curvilinear relationships. These relationships observed in 2012 are similar to what have been observed in previous years.

Introduction

Second to water, nitrogen fertility limits cotton production yields in the Texas High Plains region. Variable-rate nitrogen management based on soil NO_3 tests may save farmers N fertilizer costs and protect groundwater quality. Nitrogen applications affect cotton plant growth and development that may ultimately affect the diversity and abundance of the arthropod community in cotton fields. A three-year study conducted near Lamesa, Texas, under a limited irrigation production system (Bronson et al. 2006) characterized the effect of nitrogen application on leaf moisture and leaf nitrogen content in cotton and the resulting influence on cotton aphid population dynamics (Matis et al. 2008). Leaf nitrogen content did not vary with nitrogen application method (variable N versus blanket N application of an optimal amount), but both the blanket application and variable-rate application resulted in significantly higher leaf nitrogen contents than were noted in zero-augmented nitrogen plots. As nitrogen application rates were increased from zero to an optimum rate, a significant decrease in both aphid birth and death rates occurred, translating to a decrease in crowding and an increase in aphid survival (Matis et al. 2008). While these data were useful in characterizing cotton aphid population dynamics between zero nitrogen fertility management and optimal nitrogen application rates, the population dynamics of cotton aphids and other cotton arthropods have not been examined under a full range of nitrogen fertility rates (Parajulee 2007; Parajulee et al. 2006, 2008). In particular, no known study has produced plant growth parameters or fruiting profile data pertaining to a spectrum of nitrogen application rates in cotton. The objectives of this study were: 1) to evaluate, in cotton growing under a subsurface drip irrigation production system, cotton crop growth parameters and arthropod population abundance, as influenced by varying N fertilizer application rates, and 2) quantify cotton arthropod abundance, diversity and community structure as a function of nitrogen application rates.

Materials and Methods

The study was conducted on a five acre subsurface drip-irrigated cotton field at the Texas A&M AgriLife Helms Research Farm located two miles south of Halfway, Texas. The field was subdivided into 25 experimental plots, each 16 rows wide x 120 ft long. Five nitrogen application rates (0, 50, 100, 150, 200 lb/acre) had been deployed in a randomized block design to the same experimental units consistently for 10 consecutive years to induce maximum discrimination among treatment plots through variation in soil residual nitrogen (Fig. 1). The data and discussion reported herein are based on the 2012 crop season study.

0	50	200	50	200
100	100	0	100	50
200	150	50	150	0
50	200	100	200	100
150	0	150	0	150

Figure 1. Helms Farm nitrogen study experimental plot layout following a five nitrogen rate treatment by five replications randomized block design. Annually, each of the 25 experimental plots received one of five nitrogen augmentation treatments including 0, 50, 100, 150, or 200 pounds N/acre. Hale County, TX.

A high-yielding FiberMax cultivar, FM 9063 B2R, was planted at a targeted rate of 56,000 seeds/acre on May 17, 2012. The experiment consisted of a randomized block design with five treatments and five replications. Pre-treatment soil samples (consisting of three soil cores; 0 to 24-inch depth), collected from each of the 25 experiment plots on June 1, 2012 (Fig. 2A). The five side-dress N fertilizer application treatments at rates of 0, 50, 100, 150, and 200 lb N/acre were applied on July 6, 2012 (Fig. 2B). The effect of variable rate of N on crop phenology was visually evident toward the end of the each growing season (Fig. 2C).

Figure 2. A) Annual pre-season soil sampling of 25 sub-surface drip irrigated cotton plots; B) Annually, near the time of first bloom, each plot received one of the long-term assigned side-dressed nitrogen application treatment rates; C) Differential cotton plant growth responses are often visually apparent between plots receiving high and low N application rates. Hale County, TX.

Crop growth and insect activity were monitored during the crop season (Fig. 3A-E). Weekly during most of July and August, numerous plant variables were measured to evaluate the influence of residual soil nitrogen on early plant growth patterns. Examples of collected plant data variables included: 1) plant biomass weight, 2) plant height, 3) total leaf area, 4) percent leaf nitrogen, 5) number of 1st position cotton squares/plant, and 6) percent fruit shed. COTMAN SQUAREMAN monitoring was used to monitor early plant growth, and was followed by measurement of Nodes Above White Flower (NAWF). Foliage-dwelling mobile arthropods were monitored weekly using a 'Keep It Simple Sampler' (KISS; Beerwinkle et al. 1997; Fig. 3A) to collect the beneficial and pest arthropods from the upper-canopy foliage. Cotton aphid populations did not develop in 2012, despite two applications (August 16 and 23, 2012) of cyhalothrin intended to stimulate aphid population growth.

Two 10-ft sections were hand-harvested from each plot to obtain cotton lint and seed yields (Fig. 3F). The burr-cotton samples were processed through a research gin at the Texas A&M AgriLife Research and Extension Center, Lubbock, TX. Fiber samples from each experimental plot have been submitted to Cotton Incorporated's Fiber Testing Laboratory (North Carolina) for HVI and AFIS lint quality parameter analyses.

Figure 3. A) 'KISS" modified leaf blower with net for arthropod collections, B) Processing of arthropod samples, C) Measuring leaf chlorophyll, D) Biomass plant collections, E) Leaf area, plant root and shoot biomass measurements, and F) Cotton harvesting (low nitrogen plot visible in the forefront).

Results and Discussion

Higher levels of available residual soil nitrogen and augmented nitrogen applications significantly affected the cotton plant biomass and height during 2012. Both plant biomass and height increased continuously from 0 lb/acre up to the 150 lb/acre nitrogen applied plots (Fig. 4). Plant biomass was significantly highest in the 150 lb/acre nitrogen applied treatment, but it decreased significantly when an additional 50 lb/acre of nitrogen was applied to the 200 lb/acre N treatment plots. Likewise, the plant height increased constantly from the 0 lb/acre treatment up to the 150 lb/acre treatment, but then leveled off, resulting in similar plant heights to those in the 200 lb/acre plots. These data possibly indicate that the excess application of N fertilizer may negatively affect cotton plant growth parameters.

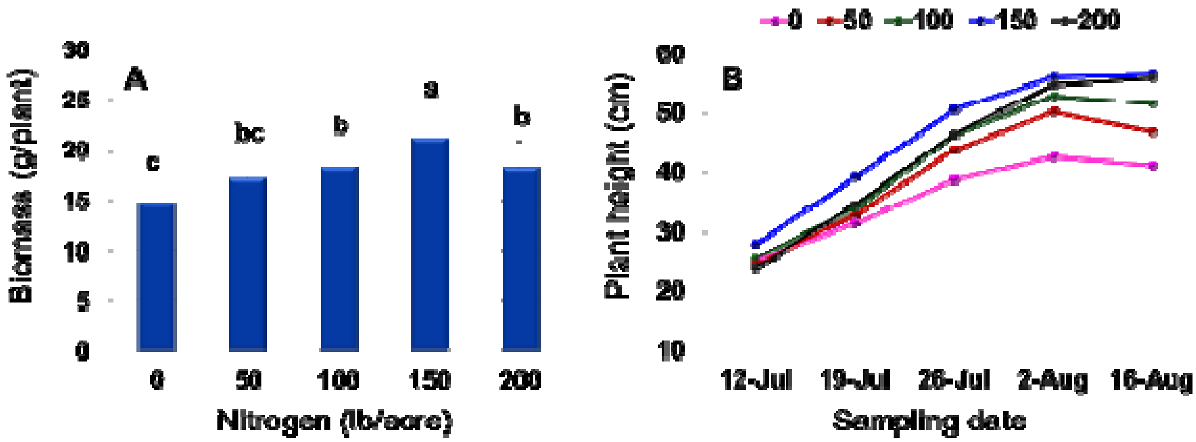

Figure 4. Effect of varied residual soil nitrogen levels and augmented nitrogen applications on plant biomass (A) and plant height (B). Hale County, TX, 2012.

Relationship between N application rate and total leaf area per plant followed similar trends to what was observed with plant biomass and height. Higher N application rates (100, 150, and 200 lb/acre) all resulted in significantly higher leaf area compared to the 0 lb/acre N treatment (Fig. 5A). When compared to the 0 lb/acre treatment, soil N augmentation treatments significantly increased the leaf nitrogen content for all nitrogen rates evaluated (Fig. 5B). High leaf nitrogen content can enhance leaf feeding herbivore populations, especially cotton aphids.

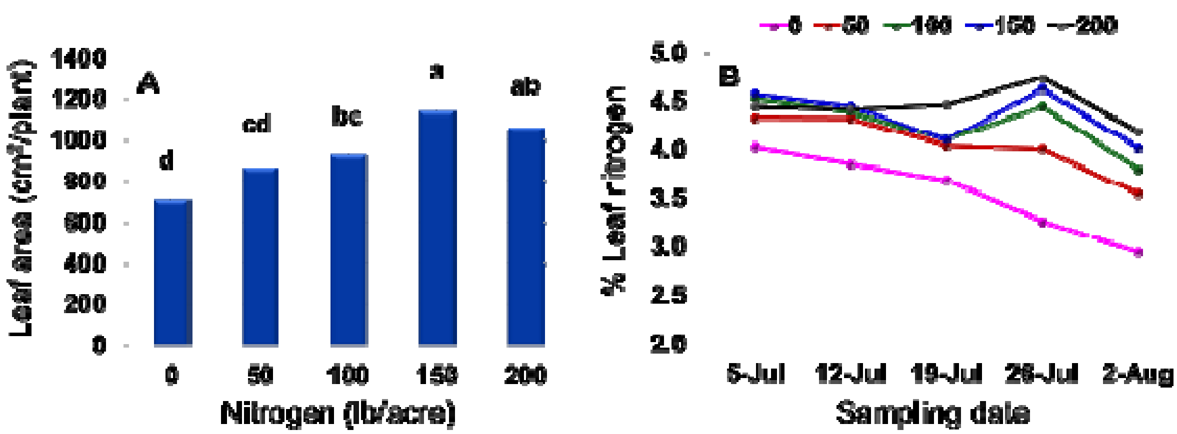

Figure 5. Effect of varied residual soil nitrogen levels and augmented nitrogen applications on leaf area (A) and leaf nitrogen content (B), Hale County, TX, 2012.

Average number of first position squares progressively increased with increased rates of N fertility, with higher N rates (100, 150, and 200 lb/acre) resulting in significantly higher number of first position squares compared to the 0 lb/acre N treatment (Fig. 6A). In the absence of major insect pressure, physiologically-induced fruit shed was low, but higher N rates favored greater fruit retention (Fig. 6B). Although fruit retention was exceptionally higher in this study due to sufficient irrigation water supplied through the drip system coupled with the absence of quantifiable insect pressure, plants would normally shed some excess fruits during the boll maturation phase. Therefore, significantly improved fruit retention at much higher N rate (e.g., 150-200 lb/acre) may not be economically relevant if the irrigation water is not sufficient to support the increased fruit load.

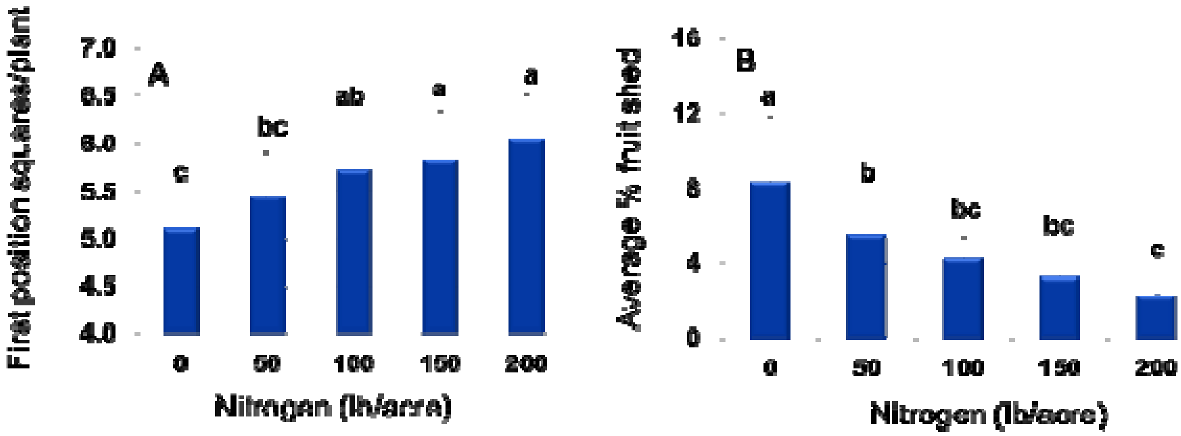

Figure 6. Effect of residual soil N levels and augmented N applications on average square retention (A) and percent fruit shed (B). Data were averaged over five sample dates (Fig. 5B) until crop cut-out. Hale County, TX, 2012.

Arthropod densities were low across all N fertility treatments during 2012. As a result, treatment effect on overall arthropod abundance was not detected (Fig. 7A). With the exception of late July, there were no significant differences in pest abundance across nitrogen treatments (Fig. 7B). In late July, the pest numbers appeared to trend higher in the lower N augmented treatments (0 and 50 lb/acre), yet we speculate that some of this difference may be due to the KISS method of sampling (Fig. 2A) possibly being less efficient on dislodging the pests from the larger and more dense high N treatment plant canopies into the sample device net. Figure 8 illustrates relative numbers of 17 cotton pest and beneficial insects monitored in each of the five N augmentation treatments. While the insect species compositions were similar across all treatments, hooded beetles were the most dominant upper canopy dwelling arthropods in all treatments (Fig. 8). This phenomenon has been the general trend over the last several years of this study. Hooded beetles are generally regarded as predatory arthropods, but we rarely observe significant abundance of prey arthropods to support such a large population of hooded beetles in our system. We speculate that these insects are more omnivorous than predatory in our cotton system.

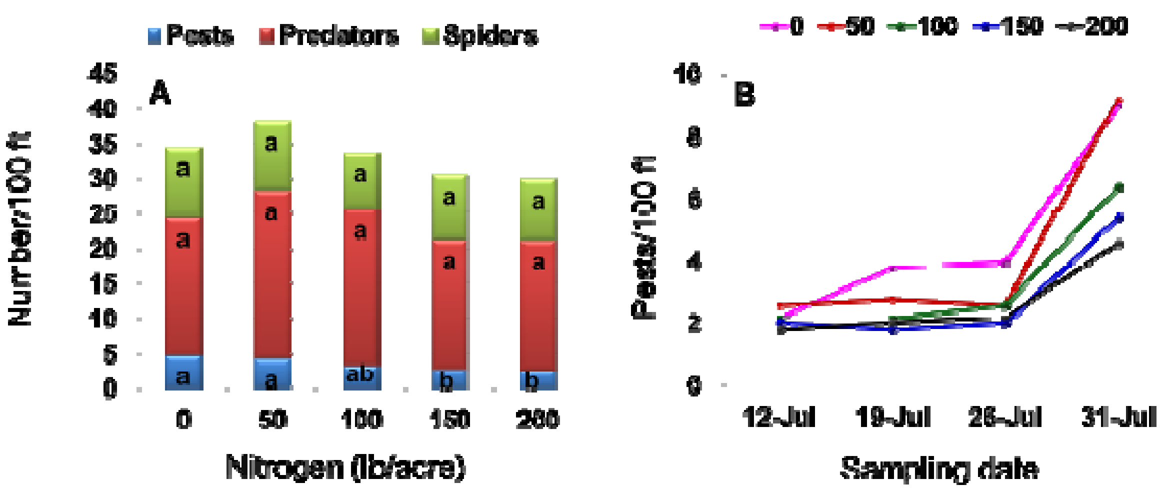

Figure 7. Effect of varied residual soil nitrogen levels and augmented nitrogen applications on total arthropod abundance (A) and pest populations (B). Hale County, TX, 2012.

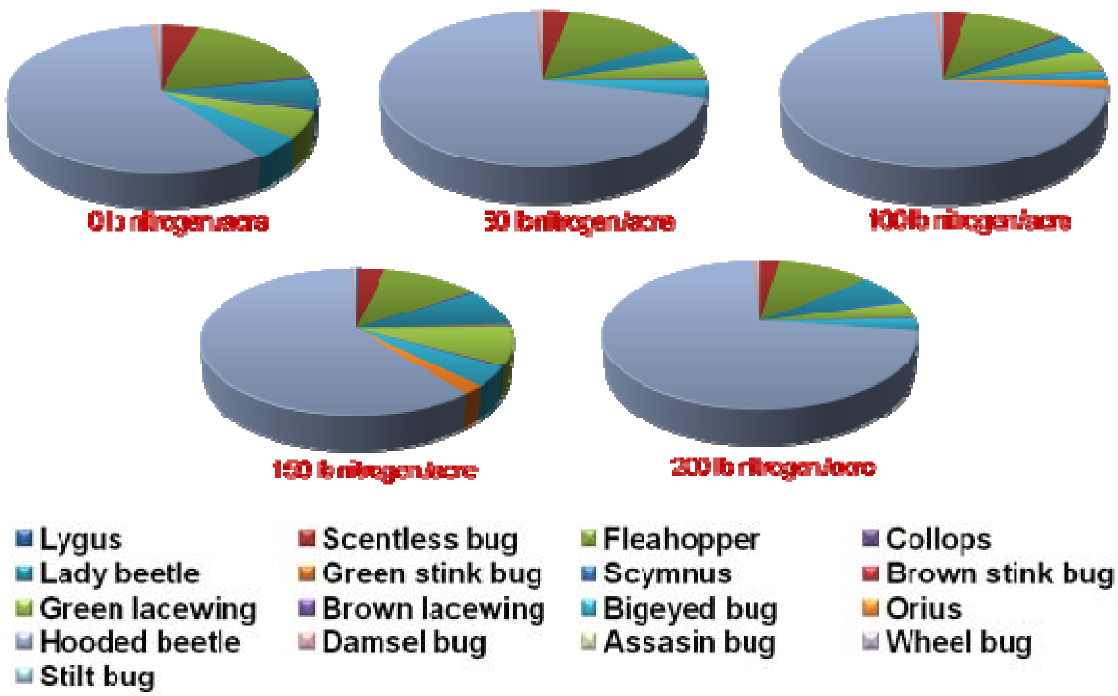

Figure 8. Effect of varied residual soil nitrogen levels and augmented nitrogen applications on seasonal insect species composition in cotton during the crop growing season. Hale County, TX, 2012.

Both cotton lint (Fig. 9A) and seed yields (Fig. 9B) increased with higher rates of nitrogen augmentation. Statistically, lint yields separated into three tiers of similar yields; lowest average yield of 1,001 lb/acre was observed on the plots receiving zero nitrogen augmentation, followed by the 50 and 100 lb/acre mid-range N augmentation rates at 1,492 and 1,625 pounds of lint per acre, respectively. The highest tier lint yields per acre averaged 2,090 and 2,145 pounds harvested from the 150 and 200 lb/acre N treatments, respectively. As expected due to the inherent seed/fiber relationship, observed seed yields followed the same 3-tiered statistical treatment yield pattern as presented above for the lint.

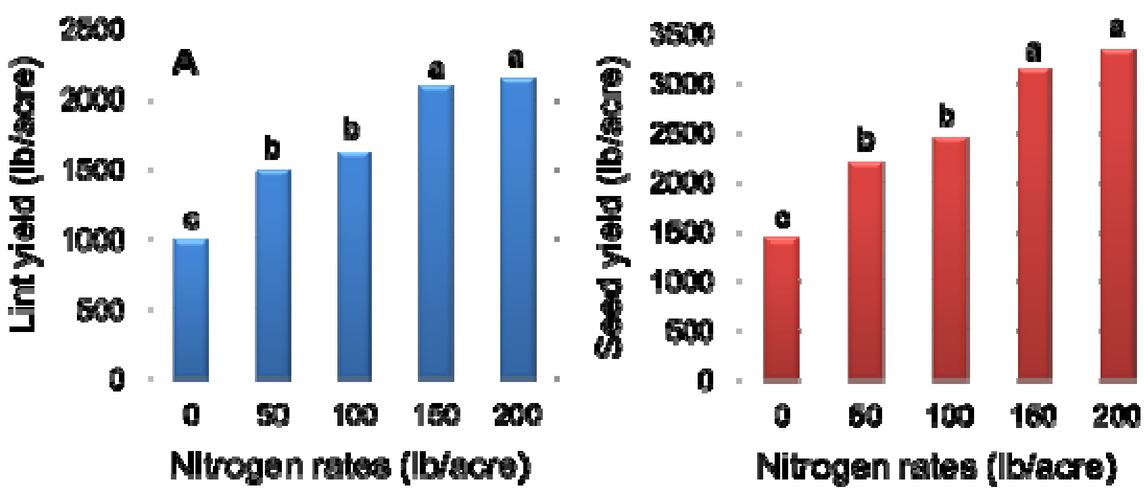

Figure 9. Effect of varied residual soil nitrogen levels and augmented nitrogen applications on cotton lint yield (A) and seed (B) yield. Hale County, TX, 2012.

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